REGULATION 5.20 Methodology for Determining Benchmark Ambient Concentration of a Toxic Air Contaminant

Air Pollution Control District of Jefferson County
Jefferson County, Kentucky

Relates To: KRS Chapter 77 Air Pollution Control
Pursuant To: KRS Chapter 77 Air Pollution Control
Necessity and Function: KRS 77.180 authorizes the Air Pollution Control Board to adopt and enforce all orders, rules, and regulations necessary or proper to accomplish the purposes of KRS Chapter 77. This regulation establishes the methodology for determining the benchmark ambient concentration for a toxic air contaminant.

SECTION 1 Use of Benchmark Ambient Concentration

A benchmark ambient concentration for a toxic air contaminant developed pursuant to this regulation shall be used in Regulation 5.21 *Environmental Acceptability for Toxic Air Contaminants* to determine environmental acceptability.

SECTION 2 Determination that a Toxic Air Contaminant is a Carcinogen

2.1 A toxic air contaminant (TAC) shall be determined to be a carcinogen if any of the following provisions is met:

2.1.1 A carcinogenic unit risk estimate, or alternatively, a concentration representative of a specified level of additional lifetime cancer risk, for the TAC is included in any of the information sources identified in sections 3.3.1 to 3.3.3 or derived by using one of the methodologies listed in section 3.3.5,

2.1.2 The TAC is listed as either "known to be a human carcinogen" or "reasonably anticipated to be a human carcinogen" in the most recent *Report on Carcinogens* published by the National Toxicology Program pursuant to Section 301(b)(4) of the Public Health Service Act as Amended by Section 262, PL 95-622, available on the Internet at "http://ehp.niehs.nih.gov/roc",

2.1.3 The TAC is classified as to potential carcinogenic risk to humans as "Group 1: The agent (mixture) is carcinogenic to humans," "Group 2A: The agent (mixture) is probably carcinogenic to humans," or "Group 2B: The agent (mixture) is possibly carcinogenic to humans" by the International Agency for Research on Cancer (IARC). The IARC list is available on the Internet at "http://www-cie.iarc.fr/monoeval/crthall.html", or

2.1.4 The District determines that the TAC should be considered to be a carcinogen because there is sufficient, credible information that any of the following criteria is met:

2.1.4.1 Known to be a human carcinogen: There is sufficient evidence of carcinogenicity from studies in humans which indicates a causal relationship between exposure to the agent, substance, or mixture and human cancer,

2.1.4.2 Reasonably anticipated to be a human carcinogen:

2.1.4.2.1 There is limited evidence of carcinogenicity from studies in humans, which indicates that causal interpretation is credible, but that alternative explanations, such as chance, bias, or confounding factors, could not adequately be excluded,

2.1.4.2.2 There is sufficient evidence of carcinogenicity from studies in experimental

animals which indicates there is an increased incidence of malignant or a combination of malignant and benign tumors: (1) in multiple species or at multiple tissue sites, or (2) by multiple routes of exposure, or (3) to an unusual degree with regard to incidence, site, or type of tumor, or age at onset, or

2.1.4.2.3 There is less than sufficient evidence of carcinogenicity in humans or laboratory animals, however; the agent, substance, or mixture belongs to a well defined, structurally-related class of substances whose members are listed in the most recent *Report on Carcinogens* published by the National Toxicology Program as either a known to be human carcinogen or reasonably anticipated to be human carcinogen, or there is convincing relevant information that the agent acts through mechanisms indicating it would likely cause cancer in humans.

2.2 In making a determination pursuant to section 2.1.3, the following provisions shall apply:

2.2.1 Conclusions regarding carcinogenicity in humans or experimental animals are based on scientific judgment, with consideration given to all relevant information. Relevant information includes, but is not limited to, dose response, route of exposure, chemical structure, metabolism, pharmacokinetics, sensitive sub populations, genetic effects, and other data relating to mechanism of action or factors that may be unique to a given substance. This applies to both the "known to be a human carcinogen" and the "reasonably anticipated to be a human carcinogen" categories, and

2.2.2 For an agent to be determined "known to be a human carcinogen," evidence from studies of humans is required. This may include traditional cancer epidemiology studies, data from clinical studies, or data derived from the study of tissues from humans exposed to the substance in question and useful for evaluating whether a relevant cancer mechanism is operating in humans.

SECTION 3 Cancer Risk Benchmark Determination Methodology

3.1 The benchmark ambient concentration for a toxic air contaminant (TAC) determined to be a carcinogen (BAC_C) shall be calculated as follows:

$$BAC_C = \frac{1 \otimes 10^{-6}}{URE} \qquad [Equation\ 1]$$

Where:

BAC_C = Benchmark Ambient Concentration for a carcinogen, a concentration representative of an additional lifetime cancer risk of 1 in 1,000,000 ($1 \otimes 10^{-6}$), in units of micrograms per cubic meter ($\mu g/m^3$),

URE = Unit Risk Estimate - Additional lifetime cancer risk occurring in a population in which all individuals are exposed continuously for life (70 years) to a concentration of 1 $\mu g/m^3$ of the chemical in the air they breathe, in units of $(\mu g/m^3)^{-1}$. The URE shall be determined according to the methodology in section 3.3, and

$1 \otimes 10^{-6}$ = An upper bound additional lifetime cancer risk of 1 in 1,000,000.

3.2 Alternatively, if in any of the sources of information identified in section 3.3, the concentration of a carcinogen, expressed in $\mu g/m^3$, that is representative of an additional lifetime cancer risk of $1 \otimes 10^{-6}$ is identified instead of the URE, then the BAC_C is that identified concentration. The URE can be calculated by using Equation 1.

3.3 The following provisions shall apply to the derivation of a unit risk estimate (URE), or alternatively a BAC_C directly, for a TAC determined to be a carcinogen:

3.3.1 If a URE for a TAC has been developed by the U.S. Environmental Protection Agency (EPA) and included in the EPA's Integrated Risk Information System (IRIS), available on the Internet at "http://www.epa.gov/iris/", then that URE shall be used to determine the BAC_C.

3.3.2 If a URE for a TAC has not been derived pursuant to section 3.3.1 but a URE for that TAC has been developed by the California Office of Environmental Health Hazard Assessment, available on the Internet at "http://www.arb.ca.gov/toxics/healthval/contable.pdf", then that URE, found in the column "Inhalation Unit Risk $(\mu g/m^3)^{-1}$, shall be used to determine the BAC_C.

3.3.3 If a URE for a TAC has not been derived pursuant to section 3.3.1 or 3.3.2 but an Initial Risk Screening Level (IRSL) for that TAC has been developed by the Michigan Air Quality Division, available on the Internet at "http://www.deq.state.mi.us/documents/deq-aqd-toxics-itslcas.pdf" sorted by Chemical Abstract Services (CAS) number or "http://www.deq.state.mi.us/documents/deq-aqd-toxics-itslalph.pdf" sorted in alphabetical order, then that IRSL shall be used as the BAC_C.

3.3.4 If a TAC has been determined to be a carcinogen, but a URE, or a BAC_C directly, has not been derived pursuant to section 3.3.1, 3.3.2, or 3.3.3, then the URE may be derived using one of the following:

3.3.4.1 The methodology in *Air Toxics Risk Assessment Reference Library, Volume 1, Technical Resource Manual, Chapter 12 Inhalation Toxicity Assessment*, U.S. Environmental Protection Agency, EPA-453-K-04-001A, April 2004, which is hereby adopted and incorporated by reference,

3.3.4.2 The methodology in *Guidelines for Carcinogen Risk Assessment*, U.S. Environmental Protection Agency, NCEA-F-0644, July 1999, Review Draft, which is hereby adopted and incorporated by reference,

3.3.4.3 The methodology in *Guidelines for Carcinogen Risk Assessment*, U.S. Environmental Protection Agency, EPA/630/R-00/004, September 24, 1986, 51 FR 33992-34003, which is hereby adopted and incorporated by reference,

3.3.4.4 The methodology in *R 336.1231 Cancer risk assessment screening methodology (2)(b) and (3)* of the *Michigan Administrative Code*, which is hereby adopted and incorporated by reference, or

3.3.4.5 Any alternative cancer risk assessment methodology that can be demonstrated to the satisfaction of the District to be more appropriate based on biological grounds and that is supported by the scientific data.

3.3.5 If a URE for a TAC has not been derived pursuant to section 3.3.1, 3.3.2, 3.3.3 or 3.3.4, then the BAC_C shall be the default value 0.0004 $\mu g/m^3$.

3.4 An annual average time period shall be used for a BAC_C.

SECTION 4 Chronic Noncancer Risk Benchmark Determination Methodology

The benchmark ambient concentration for the noncarcinogenic effects of a toxic air contaminant (BAC_{NC}), a concentration that is likely to be without an appreciable risk of deleterious effects during a lifetime, shall be determined as follows:

4.1 If a Reference Concentration (RfC) for a TAC has been developed by the EPA and included

in the EPA's Integrated Risk Information System (IRIS), available on the Internet at "http://www.epa.gov/iris/", then that RfC shall be used as the BAC_{NC}:

$$BAC_{NC} = RfC \qquad \text{[Equation 2]}$$

Where:

BAC_{NC} = Benchmark Ambient Concentration for the noncarcinogenic effects of a TAC, in units of $\mu g/m^3$, and

RfC = Reference Concentration, in units of $\mu g/m^3$.

A 24-hour average time period shall be used for a BAC_{NC} determined pursuant to section 4.1.

4.2 If a BAC_{NC} for a TAC has not been determined pursuant to section 4.1 but a Reference Exposure Level (REL) for that TAC has been developed by the California Office of Environmental Health Hazard Assessment, available on the Internet at "http://www.arb.ca.gov/toxics/healthval/contable.pdf", then that REL, found in the column "Chronic Inhalation ($\mu g/m^3$), shall be used as the BAC_{NC}:

$$BAC_{NC} = REL \qquad \text{[Equation 3]}$$

Where:

BAC_{NC} = Benchmark Ambient Concentration for the noncarcinogenic effects of a TAC, in units of $\mu g/m^3$, and

REL = Reference Exposure Level, in units of $\mu g/m^3$.

A 24-hour average time period shall be used for a BAC_{NC} determined pursuant to section 4.2.

4.3 If a BAC_{NC} for a TAC has not been determined pursuant to section 4.1 or 4.2 but an Oral Reference Dose (RfD) for that TAC has been developed by the EPA and included in the EPA's IRIS, available on the Internet at "http://www.epa.gov/iris/", and data are not available to indicate that oral-route to inhalation-route extrapolation is inappropriate, then that RfD shall be used to calculate the BAC_{NC} as follows:

$$BAC_{NC} = Oral\ RfD \otimes \frac{70\ kg}{20\ \frac{m^3}{day}} \qquad \text{[Equation 4]}$$

Where:

BAC_{NC} = Benchmark Ambient Concentration for the noncarcinogenic effects of a TAC, in units of $\mu g/m^3$,

RfD = Reference Exposure Level, in units of $\mu g/kg\text{-}day$,

70 kg = The average body weight of a human, and

20 m^3/day = The average daily inhalation rate for a human.

A 24-hour average time period shall be used for a BAC_{NC} determined pursuant to section 4.3.

4.4 If a BAC_{NC} for a TAC has not been determined pursuant to section 4.1 to 4.3 but an Initial Threshold Screening Level (ITSL) for that TAC has been developed by the Michigan Air Quality Division, available on the Internet at "http://www.deq.state.mi.us/

documents/deq-aqd-toxics-itslcas.pdf" sorted by Chemical Abstract Services (CAS) number or "http://www.deq.state.mi.us/documents/deq-aqd-toxics-itslalph.pdf" sorted in alphabetical order, then that ITSL shall be used as the BAC_{NC}:

$$BAC_{NC} = ITSL \qquad \text{[Equation 5]}$$

Where:

BAC_{NC} = Benchmark Ambient Concentration for the noncarcinogenic effects of a TAC, in units of $\mu g/m^3$, and

ITSL = Initial Threshold Screening Level, in units of $\mu g/m^3$.

The average time period as listed for a specific ITSL shall be used for a BAC_{NC} determined pursuant to section 4.4.

4.5 If a BAC_{NC} for a TAC has not been determined pursuant to section 4.1 to 4.4 but an occupational exposure level (OEL) exists for that TAC, then the OEL may be used to calculate the BAC_{NC} as follows:

$$BAC_{NC} = \frac{OEL}{100} \qquad \text{[Equation 6]}$$

Where:

BAC_{NC} = Benchmark Ambient Concentration for the noncarcinogenic effects of a TAC, in units of $\mu g/m^3$,

OEL = Occupational Exposure Level, that, for the TAC, is the lowest value of either the National Institute of Occupational Safety and Health (NIOSH)-recommended exposure level listed in current edition of the NIOSH pocket guide to chemical hazards or the time-weighted average or ceiling Threshold Limit Value (TLV) listed in the current edition of the American Conference of Governmental and Industrial Hygienists Threshold Limit Value (TLV) booklet, in units of $\mu g/m^3$, and

100 = A composite safety factor to account for differences in susceptibility between the healthy, adult worker population compared to the general population that is more diverse and may contain individuals or subpopulations more sensitive to the effects of the toxic air pollutant (safety factor of 10). Additionally, the composite safety factor accounts for the difference in exposure duration (in hours per week and years working versus a lifetime) for the worker population compared to the general population:

$$\frac{1}{10} \otimes \frac{40\ hours/week}{168\ hours/week} \otimes \frac{30\ years}{70\ years} \approx \frac{1}{100}.$$

An 8-hour average time period shall be used for a BAC_{NC} determined pursuant to section 4.5 based upon a time-weighted OEL and a 1-hour average time period shall be used for a BAC_{NC} determined pursuant to section 4.5 based upon a ceiling OEL.

4.6 If a BAC_{NC} for a TAC has not been determined pursuant to section 4.1 to 4.5 but a 7-day, inhalation, no observed adverse effect level (NOAEL) or lowest observable adverse effect level (LOAEL) is available for that TAC, then the NOAEL or LOAEL may be used to calculate the BAC_{NC} as follows:

$$BAC_{NC} = \frac{NOAEL}{35 \otimes 100} \otimes \frac{Hr\ Exposed\ /\ Day}{24\ Hr\ /\ Day} \qquad [Equation\ 7]$$

$$BAC_{NC} = \frac{LOAEL}{35 \otimes 100 \otimes UF} \otimes \frac{Hr\ Exposed\ /\ Day}{24\ Hr\ /\ Day} \qquad [Equation\ 8]$$

Where:

BAC_{NC} = Benchmark Ambient Concentration for the noncarcinogenic effects of a TAC, in units of $\mu g/m^3$,

NOAEL = No observed adverse effect level (inhalation study), in units of $\mu g/m^3$,

LOAEL = Lowest observed adverse effect level (inhalation study), in units of $\mu g/m^3$,

35 = A safety factor to account for using a NOAEL or LOAEL from a 7-day exposure period to estimate a NOAEL or LOAEL for a lifetime study,

100 = A standard composite safety factor comprised of a safety factor of 10 to account for differences between animals and humans and a safety factor of 10 to account for the differences between individuals in the human population, and

UF = Uncertainty Factor, a value from 1 to 10, applicable when using a LOAEL (lowest effect) instead of a NOAEL (no effect), determined by the District on a case-by-case basis, considering the type and severity of effect. For example, a value of 1 would be used when the lowest effect was a skin rash; a value of 10 would be used when the lowest effect was death.

If approved by the District, the BAC_{NC} may be determined on a case-by-case basis using a NOAEL or LOAEL from repeated dose studies other than 7-day studies.

An annual average time period shall be used for a BAC_{NC} determined pursuant to section 4.6.

4.7 If a BAC_{NC} for a TAC has not been determined pursuant to section 4.1 to 4.6 but a 7-day, oral NOAEL or oral LOAEL is available for that TAC, then the oral NOAEL or oral LOAEL may be used to calculate the BAC_{NC} as follows:

$$BAC_{NC} = \frac{Oral\ NOAEL}{35 \otimes 100} \otimes \frac{W_A}{I_A} \otimes \frac{b}{a} \qquad [Equation\ 9]$$

$$BAC_{NC} = \frac{Oral\ LOAEL}{35 \otimes 100 \otimes UF} \otimes \frac{W_A}{I_A} \otimes \frac{b}{a} \qquad [Equation\ 10]$$

Where:

BAC_{NC} = Benchmark Ambient Concentration for the noncarcinogenic effects of a TAC, in units of µg/m³,
NOAEL = No observed adverse effect level (oral study), in units of µg/kg-day,
LOAEL = Lowest observed adverse effect level (oral study), in units of µg/kg-day,
35 = A safety factor to account for using a NOAEL or LOAEL from a 7-day exposure period to estimate a NOAEL or LOAEL for a lifetime study,
100 = A standard composite safety factor comprised of a safety factor of 10 to account for differences between animals and humans and a safety factor of 10 to account for the differences between individuals in the human population,
UF = Uncertainty Factor, a value from 1 to 10, applicable when using a LOAEL (lowest effect) instead of a NOAEL (no effect), determined by the District on a case-by-case basis, considering the type and severity of effect. For example, a value of 1 would be used when the lowest effect was a skin rash; a value of 10 would be used when the lowest effect was death,
W_A = Body weight of experimental animal in kilograms (kg),
I_A = Daily inhalation rate of experimental animal in m³/day,
b = Absorption efficiency (percent absorbed) by the oral route of exposure, and
a = Absorption efficiency (percent absorbed) by the inhalation route of exposure.

If approved by the District, the BAC_{NC} may be determined on a case-by-case basis using an oral NOAEL or oral LOAEL from repeated dose studies other than 7-day studies.

An annual average time period shall be used for a BAC_{NC} determined pursuant to section 4.7.

4.8 If a BAC_{NC} for a TAC has not been determined pursuant to section 4.1 to 4.7 but an inhalation LC_{50} from a study that is 4 or more hours in duration is available for that TAC, then the LC_{50} may be used to calculate the BAC_{NC} as follows:

$$BAC_{NC} = \frac{LC_{50}}{500 \otimes 100} \qquad \textbf{[}\textit{Equation}\ 11\textbf{]}.$$

Where:
BAC_{NC} = Benchmark Ambient Concentration for the noncarcinogenic effects of a TAC, in units of µg/m³,
LC_{50} = Concentration of material used in an inhalation study that causes death of 50% of the group of test animals when administered as a single dose in a specific time period, in units of µg/m³,
500 = A factor to account for using an LC_{50} to estimate a no observed adverse effect level (NOAEL) for a lifetime study, and
100 = A standard composite safety factor comprised of a safety factor of 10 to account for differences between animals and humans and a safety factor

of 10 to account for the differences between individuals in the human population.

An annual average time period shall be used for a BAC_{NC} determined pursuant to section 4.8.

4.9 If a BAC_{NC} for a TAC has not been determined pursuant to section 4.1 to 4.8 but an LC_{50} from a 1-hour inhalation study is available for that TAC, then the 1-hour LC_{50} may be used to calculate the BAC_{NC} as follows:

$$BAC_{NC} = \frac{(1-Hr)\ LC_{50}}{500 \otimes 100 \otimes 40} \qquad [Equation\ 12].$$

Where:

BAC_{NC} = Benchmark Ambient Concentration for the noncarcinogenic effects of a TAC, in units of $\mu g/m^3$,

LC_{50} = Concentration of material used in an inhalation study that causes death of 50% of the group of test animals when administered as a single dose in a specific time period, in units of $\mu g/m^3$,

500 = A factor to account for using an LC_{50} to estimate a no observed adverse effect level (NOAEL) for a lifetime study,

100 = A standard composite safety factor comprised of a safety factor of 10 to account for differences between animals and humans and a safety factor of 10 to account for the differences between individuals in the human population, and

40 = A safety factor to account for the uncertainty of using a one-hour inhalation LC_{50} compared to an exposure duration of four hours or more.

An annual average time period shall be used for a BAC_{NC} determined pursuant to section 4.9.

4.10 If a BAC_{NC} for a TAC has not been determined pursuant to section 4.1 to 4.9 but an animal oral LD_{50} is available for that TAC, then the LD_{50} may be used to calculate the BAC_{NC} as follows:

$$BAC_{NC} = \frac{LD_{50}\ (mg/kg)}{500 \otimes 100 \otimes 40 \otimes 0.167} \otimes \frac{W_A}{I_A} \qquad [Equation\ 13].$$

Where:

BAC_{NC} = Benchmark Ambient Concentration for the noncarcinogenic effects of a TAC, in units of $\mu g/m^3$,

LD_{50} = Amount of material administered in a single dose by a route other than inhalation, e.g., oral, that causes death of 50% of the group of test animals, in units of $\mu g/kg$,

500 = A factor to account for using an LC_{50} to estimate a no observed adverse effect level (NOAEL) for a lifetime study,

100 = A standard composite safety factor comprised of a safety factor of 10 to account for differences between animals and humans and a safety factor

of 10 to account for the differences between individuals in the human population,

40 = A safety factor to account for the uncertainty of estimating an LC_{50} from an LD_{50},

0.167 = A factor to convert the daily dose to a 4-hour time frame (4 ÷ 24 = 0.167),

W_A = Body weight of experimental animal in kilograms (kg), and

I_A = Daily inhalation rate of experimental animal in m^3/day.

An annual average time period shall be used for a BAC_{NC} determined pursuant to section 4.10.

4.11 If a BAC_{NC} for a TAC has not been determined pursuant to section 4.1 to 4.10, then the BAC_{NC} shall be the default value:

$$BAC_{NC} = 0.04\ \mu g/m^3 \qquad \text{[Equation 14].}$$

Where:

BAC_{NC} = Benchmark Ambient Concentration for the noncarcinogenic effects of a TAC, in units of $\mu g/m^3$.

An annual average time period shall be used for a BAC_{NC} determined pursuant to section 4.11.

4.12 Notwithstanding the methodologies in sections 4.3, 4.7, and 4.10, a BAC_{NC} shall not be derived from one of these methodologies, which consider route-to-route extrapolation, unless the District has affirmatively determined that the use of oral toxicity data is appropriate. The use of oral toxicity data is not appropriate in the following cases:

4.12.1 When groups of chemicals have different toxicity by the two different routes (e.g., metals, irritants, and sensitizers),

4.12.2 When a first-pass effect by the respiratory tract is expected,

4.12.3 When a first-pass effect by the liver is expected,

4.12.4 When a respiratory tract effect is established, but dosimetry comparison cannot be clearly established between the two routes,

4.12.5 When the respiratory tract is not adequately studied in the oral studies, and

4.12.6 When short-term inhalation studies, dermal irritation, in vitro studies, or characteristics of the chemical indicate potential for portal-of-entry effects at the respiratory tract, but studies themselves are not adequate for the development of a benchmark ambient concentration.

SECTION 5 Consideration of Acute Noncancer Effects

If the District determines that compliance with the BAC_{NC} over the applicable averaging time specified in Section 4 does not provide adequate protection from the acute effects of a TAC, then the District may establish a different acute benchmark ambient concentration (BAC_{NCA}) and shorter averaging time that would provide adequate protection.

SECTION 6 Available Documents

The District will maintain on its web page, "http://www.apcd.org", links to the documents identified as available on the Internet and maintain at its office a copy of all documents identified in this regulation. In addition, the District will maintain a current list of the benchmark ambient concentrations that have been developed pursuant to this regulation and maintain this current list on its web page.

Adopted v1/_____ ; effective _____.